Engineering

TARGETING ORBITS IN THE CIRCULAR RESTRICTED 3-BODY SYSTEM

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When studying the orbit of a small body (such as a satellite) in the vicinity of major bodies (such as planets and moons), it is often convenient to consider the gravitational fields of only the two closest major bodies. As long as the remaining major bodies are sufficiently distant, their effects can be later modelled as perturbations. Such a formulation is generally denoted as a *Restricted 3-Body System*, since the small body has an insignificant mass. A rotating body-body reference frame is also employed to further simplify the equations of motion for this system. This type of reference frame is defined with an origin at the center of mass of the system, and the major axis is directed from one major body toward the other. Its rotation is a consequence of the two major bodies orbiting their common center of mass. The model can be further simplified, if it is assumed that the two major bodies orbit each other in circular motion (which implies a constant rate of rotation). The resulting system is then labeled a *Circular Restricted 3-Body System*. It is possible to identify a certain constant of the satellite's motion which aids in generalizing forms of the orbits, and also allows a determination of the accuracy of the numerical integration process. In addition, the equations of motion reveal five special equilibrium points in the system, called *Equilibrium* or *Libration Points*. The locations of the Libration Points are fixed relative to the rotating coordinate frame, and thus remain in the space near the two major bodies. The points possess some interesting and useful stability properties and are, therefore, attractive locations for experiments conducted in space.

In this paper, the focus is an attempt to transfer a satellite from an orbit around Earth to an orbit around the fourth Libration Point (L4) in the rotating Earth-Moon System. The initial step to accomplish this task is an analysis of the types of trajectories that surround L4. Second, families of trajectories are determined that depart Earth and eventually arrive in the vicinity of L4. The final step involves matching these two trajectories in position to minimize the amount of fuel used during the entire mission.

The methods described in this paper could be used to obtain a preliminary guess for an actual trajectory of this type. However, the Sun, with its gravity and radiation pressure, does in fact play a significant role in the trajectory design. Therefore, the estimated mission expenses (in terms of the required ΔV) cannot be interpreted as exact values; more detailed mission analysis must always be involved. However, the approach is still quite useful for a quick and approximate comparison of different trajectories.